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DISSERTATION TITLE: *“Beamforming Microphone Arrays for Audio Applications”*

The objective of this thesis is to develop novel methods for microphone array processing in order to provide high quality spatially focused audio, primarily for speech applications. In situations where close-talking microphones are not applicable, or when sound acquisition is done in a noisy environment, an array of microphones can improve the quality of the acquired sound.

Microphone array speech enhancement is achieved by combining outputs from the multiple microphones of the array into a single, improved output signal. The algorithms representing the rules for combining the microphone signals are commonly referred to as beamformers. The choice of the beamformer, together with the design of the microphone array itself, will determine the overall improvement that an array has to offer compared to a conventional microphone. The main challenge of array processing for speech applications is the large physical size of the array required due to the broadband nature of the signals. Real-time signal processing of a large number of audio channels is another challenge, especially when an adaptive beamformer is needed. Adaptive beamformers are computationally demanding and often not suitable for arrays of hundreds of sensors aimed at real-time applications. In this thesis we address all these challenges. Some of the main results can be summarized as following:

- Design and a feasibility study of a large, real-time MEMS microphone array system for speech acquisition in extremely noisy environments.
- Processing-efficient implementation of an adaptive beamformer for a large microphone array.
- Speeding up digital beamforming by GPU processing.
- Optimal design of a circular array for phase-mode beamforming.
- New beamformer design technique for spherical microphone arrays.
- Application of the previously developed solutions.

This work has been conducted under BAB project (broad band audio beam), a collaboration project between *Digital Signal Processing and Image Analyses Group* and *Squarehead Technology AS*. The project was supported by the *Research Council of Norway*.